

RENAULT FAURECIA METHODOLOGY FOR DESIGN OF THE SEAT AS A RESTRAINT SYSTEM.

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Abstract.

This study is the result of 2 years of work between the Renault safety department and the Faurecia R&D department. The paper is based on 5 different items aimed at developing improved occupant safety and controlling development of the safety components :

- definition of different crash configurations and the associated biomechanical criteria by the car manufacturer.
- definition of functional specifications (geometry and stiffness for each component) using global simulations. This is the starting point for discussions between the car manufacturer and the suppliers. Comparison of the specifications to the state of the art gives the first orientations for future developments.
- An exchange of simulation data to allow overall simulations as early as possible by the supplier's simulation department: Each component can be represented by springs or contact interfaces in the different calculation programs. This simplifies the simulation without the need to exchange information on supplier expertise or technical solutions.
- Definition of common numerical tools and specific outputs: The supplier's global simulation method is compared to Renault's and an objective result is obtained. The performance of each component in the global configuration has to be evaluated with special outputs called force balance.
- Creation by the supplier of a technical solutions database to reduce development times for new projects.

Introduction.

Reliable safety performance is based on accurate knowledge of accident data, which gives us information about the most frequent and severe crash configurations which need to be given priority. This expertise has to be coupled with biomechanical data in order to reduce injury risks. These biomechanical studies have particularly to take into account the relationship between injury risk and age in order to improve occupant safety even for older people. All parts of the body have to be protected to avoid mortal or long term injuries. Accident data shows that developments in airbags and shoulder belt load limiting systems have reduced the injury risk for the head, the neck and

the thorax. The main goal has now become protection of the pelvis, lumbar spine and lower limbs. The study attacks this problem : How can we control occupant pelvis movement, use the seat as a restraint system and avoid risk for the lumbar spine ?

General problematic

On the supplier point of view, a usual problematic connected to safety is:

- to anticipate on the OEM's need: being aware of his strategy, which in the case of Renault consists in real safety, to confirm his top class ranking in different ratings. More focussing on seats, already softly coupled with it's occupants, to improve this equipment participation in front crashes on the basis of accident data states and trends, as mentioned above.
- to be ready to integrate and understand the data and requests, having made an advanced work of tools validation and acceptance: having common advanced programs with him and/or his partners. In our example, a common program to establish new criteria for advanced protection of lower limbs has been performed with LAB and CEESAR. At the same time, a common tool was designed in order to quantify the quality of math models and ensure the same understanding of what a validated model should be.
- to dispose of a panel of standards and innovations, with a certain level of transversalities and be able to act on mastered parameters of those ones to fulfill the need in the shortest time (active/passive seat systems)
- to work in an overall environment for the optimal dimensioning of the proposed equipment which most of the time (every time!) are only part of a complete solution to which several other equipment (suppliers) participate. Assuming that time is one of the main success factors and that exchanges between all involved suppliers are not so easy in sometimes (always) context of competition and confidentiality, the designed solution consisted in "Black Boxes" types exchanges

through so called phase I models translating biomechanical need into targets for the different equipment's behavior (design functions). Assuming also that the final quotation in consumers ratings like Euro NCAP are made on cars, only the car manufacturer could take responsibility of the safety synthesis.

Definition of crash configurations with associated biomechanical targets measured on the dummies.

Accident data gives us good information about the frequency and the severity of different crash configurations for frontal, side & rear impacts, rollover, etc. These data have to be related to the risk of injury. From this information it is possible to determine the velocity and crash configurations to be taken into account for the development of structure and restraint systems which give real improvements in occupant safety performance and meet regulation / rating requirements.

Biomechanical studies give us a better understanding of human tolerance in each area of the body, taking into account occupant age or size. Injury risk can be estimated from these data for the usual criteria : deflection, force, moment, acceleration. Using transfer functions from human to dummy, we can define targets which give good occupant protection even for older people.

All these data can be combined to define general specifications with a relation between biomechanical targets and severity of the crash. New criteria can be introduced which are not yet included in the regulations : movement of the pelvis has to be controlled taking into account the force and momentum transferred to the lumbar spine.

Definition of functional specifications using global simulations.

Biomechanical criteria measured on the dummy have to be translated into forces applied by the different safety components to the different body regions. For example the lap belt, the seat, the dashboard (through the femurs) and the lumbar spine apply forces to the pelvis (Picture 1).

The distribution and balance of the component behaviors control movement of the occupant inside the vehicle. These estimations use finite element or rigid body models. For each component, a target behavior is defined in the global model. The target behavior is defined by a force / deformation curve and with the energy to be absorbed. A functional specification is defined without reference to the technical solution which will give the correct result. These target behaviors are the starting point for preliminary discussions between the car

manufacturer and each supplier: Both companies can check very early whether existing technologies correspond to the target behavior (shelves of standards or innovations) or if new developments are necessary.

Target behavior for a seat has to take into account crashworthiness, anti submarining, and protection of the lumbar spine/pelvis/lower limbs complex. All the frontal dummies can be used to check all these items. The target behavior has to be associated with a sub system test or calculation. This sub system configuration is used to test the component alone before using it in a global configuration with sled facilities or a vehicle. The force / deformation curve and the force direction are used to define initial and boundary conditions for the sub-system configuration : drop fall tests, pendulum tests or even a static press can be used for sub-system configurations. These sub-system tests or calculations give faster results for a lower cost and allow performance to be better controlled in the overall context.

Relevant tools and process

Dummies: to perform real safety, we need to use as much as possible human like models. A specific model was developed in the Radioss software, representing correctly the regulation Hybrid III and integrating more biofidel functions such as in lumbar region.

Phase I acceptance: Once the functional specifications are made from overall models, the transfer to each of the potential partners is made. At that time, conditions of continuity are linked to direct integration of those ones. In an optimal way (never), the same software is used, the same dummy is used, in the same development phase. In a more real world, the supplier does not use the same tools at the same period of development and some adaptations and verifications are necessary to validate the supplier's models. This is the goal of Modeval (Picture 2), specific software developed in collaboration with Renault and Ceasar in order to quantify the quality of a model in an objective way. Most of the time papers are presented in congresses, showing math models and correlation levels. A graph is usually proposed, lighting, on compressed scales the "good validation" of the model versus the "equivalent test". In the safety restraint activity, approximation can not be suffered. A short deviation in timing between dashboard and seat participation for example can lead to complete redistribution of energies and completely false conclusions and designs. Modeval was developed to avoid all subjective assessments. The use of this software is now the only way to

validate phase I models as input data, even when translated from one software to another.

Phase I,5 pre design: The goal is defined and validated, the design function has been integrated and understood in the overall restraint environment. Choice is made after comparison of available standards and innovation shelves performance and needed function. Adjustments of parameters are made in phase I,5 calculations, consisting in running rough FE models of the seat design considered as nearest to the target (Picture 4). At that time, it's not necessary to use complete FE models, too rich and heavy for fast iterations and convergence to the performance. On the same design philosophy, sub systems tests are performed, on the basis of overall simulations initial conditions (Delta V, directions of impacts, ...). The duality simulation/tests (Picture 3) in constant communication and improvements leads to shorten development time and more quality oriented experience database constitution. Once the performance is accepted, architectural choice is made and optimization phase begins, integrating all constraints more deeply (comfort, process, style, integration of different systems...).

Conclusions.

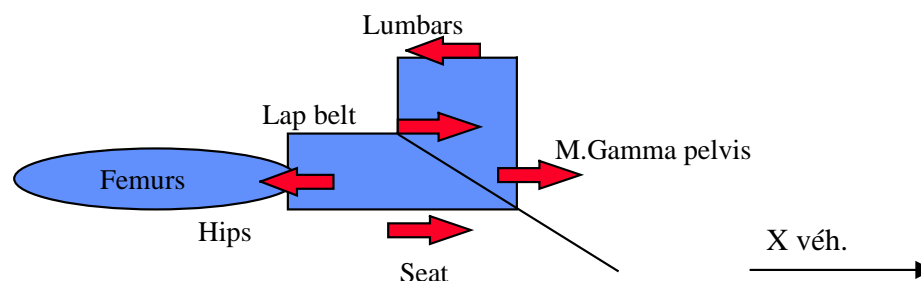
The methodology presented in this paper for the seat is sufficiently generic to be used for all safety components.

Global safety performance is controlled by the car manufacturer using global simulation to define target behaviors and the safety strategy for a given vehicle. These simulations are based on an energy management approach :

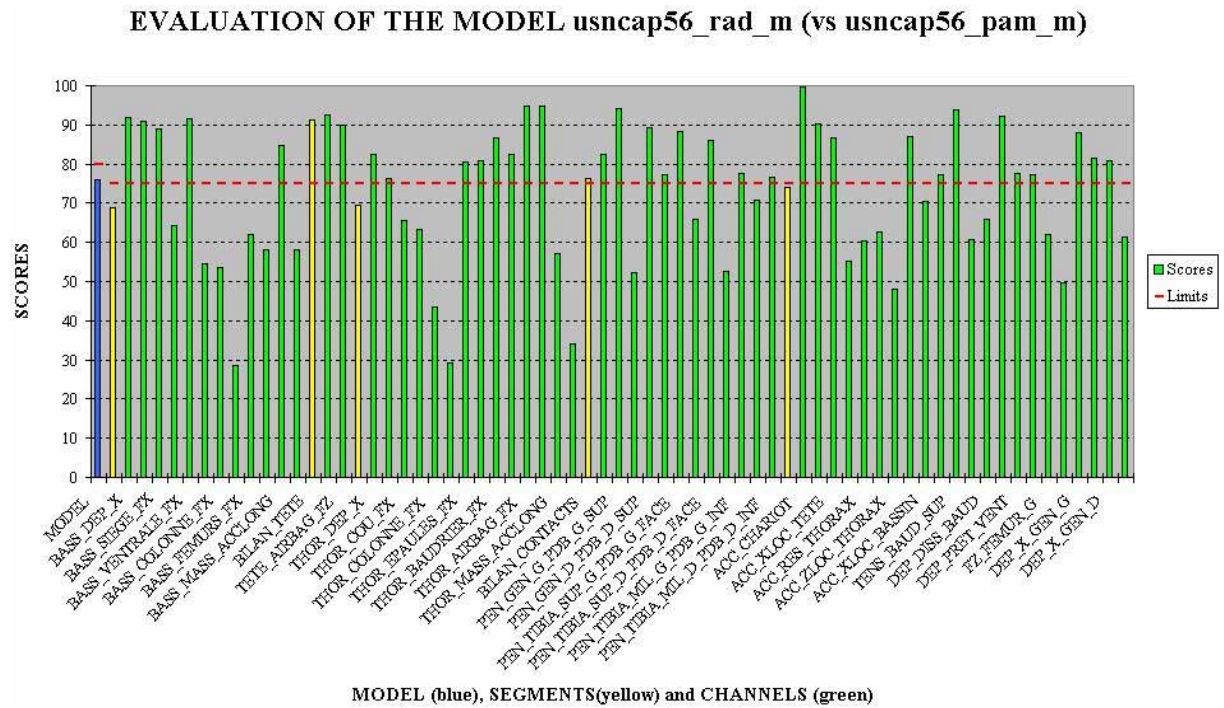
- Division of the energy to be absorbed between the different components.
- Definition of sub system tests or calculations to control force-deformation behavior.
- Definition of specific outputs in the global simulation.

These target behaviors can be easily exchanged for implementation in the different calculation programs used by the suppliers. The main goal of this methodology is to facilitate the discussions between partners using objective criteria throughout vehicle development, with reductions in time and cost.

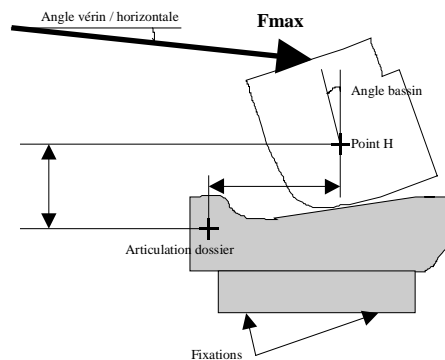
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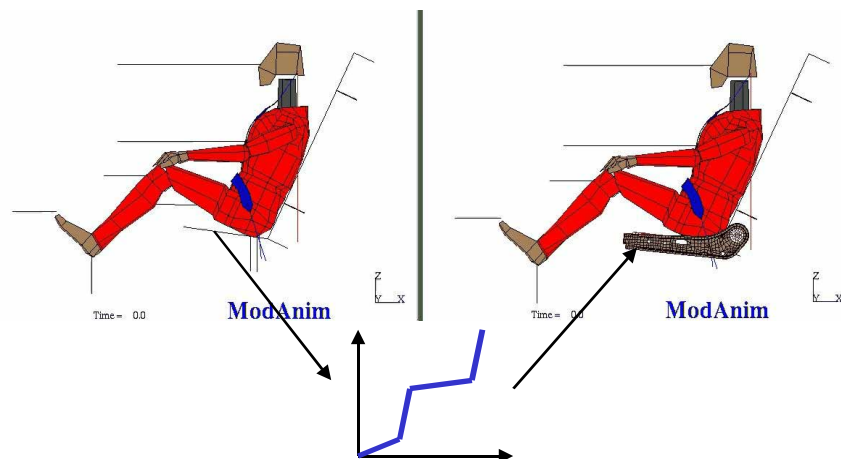
Picture 1: Forces balance on pelvis



Picture 2: Example of objective Model quality assessment with Modeval



Picture 3: sub system test & simulation configuration on seat cushion



Picture 4: From mass springs models (phase I) to detailed functions (phase II)